CHAPTER 8

SEISMIC INSTRUMENTATION

8-1. Introduction. The failure of a concrete dam or intake tower when subjected to an earthquake could have serious consequences. Although earthquake forces are considered in the design of structures, data obtained from instrumentation during earthquakes have indicated significantly different results when compared to those anticipated in design. Instrumentation should be installed in regions of significant seismic activity to measure ground motion, hydrodynamic water pressures, and response of concrete dams and intake towers 100 ft or more in height. Also, seismic instrumentation may be desired at other locations where the structure and seismic activity are unusual. Each project should be instrumented to suit the particular structure, geologic and seismic condition. Reference is made to EM 1110-2-1908, Part 2, dated November 1976, which describes instruments, techniques, and methods of analysis used to monitor seismic activity. The chapter written here is intended for informational purposes only.

8-2. Description.

a. Types. Instruments used to obtain a seismic data are strong-motion accelerometers, peak recording accelerometers, hydrodynamic pressure gages, and seismoscopes.

b. Strong-Motion Accelerometers. These instruments contain accelerometers which measure the acceleration of a mass due to strong, quick motions. They generally contain three accelerometers oriented orthogonally which are activated under forces of 0.5 or 1.0 g's by a pendulum device.

C. Peak Recording Accelerometers. The inexpensive peak recording accelerometer detects and records peak amplitudes of low-frequency accelerations and is used to supplement data obtained from conventional accelerometers. The peak acceleration is recorded by erasure of prerecorded units on l/4-in. magnetic tape with a total error bank of + 5 percent. The device is available with sensitivities varying from 0.1 to 10 g.

d. Hydrodynamic Pressure Gages. These gages measure the increase in water pressure when subjected to additional inertial forces of liquids associated with earth motion. Instruments consist of a Carlson type strain meter, with recording device activated by an accelerometer.

e. Seismoscopes. The seismoscope is an inexpensive device that indicates the occurrence of an earthquake but does not write a time record of the forces associated with it. The instrument consists of a free conical pendulum that can move in any horizontal direction to record the response of a single-degree-of-freedom system of prescribed period and damping to the earthquake ground motion. It records direction of motion and indicates relative intensity. Installation of seismoscopes in new projects is not recommended. It has been observed in the past that the information obtained from these instruments has been difficult to interpret and thus not of significant value. Policy on seismoscopes should be to maintain any such instruments that are already installed, but not to install new ones.

8-3. Design Considerations. The instruments mentioned in paragraph 8-2 should be installed in all concrete dams and intake towers over 100-ft high in seismic Zones 2, 3, and 4 shown on the seismic zone map in ER 1110-2-1806. The seismic instruments should be procured and installed by the Government. The instruments selected should be based on the type of structure and its seismic zone. Concrete dams over 200 ft in height in Zones 3 and 4 should be instrumented with four strong-motion accelerometers; and since the actual accelerations during earthquakes may exceed the accelerometer ranges, particularly in Zones 3 and 4, peak recording accelerometers should be provided to supplement the strong motion accelerometers. Concrete dams between 100 and 200 ft in height in Zones 3 and 4 and over 100 ft in height in Zone 2 west of longitude 106°W, should be instrumented with three strong-motion accelerometers supplemented by peak reading accelerometers. In dams with three or more strong-motion accelerometers, one should be located on top of one of the higher dam monoliths, one in the upstream gallery near the base of the same monolith, and one of the bedrock foundation at a distance downstream of the toe of about three times the dam height. For the larger structures (about 200 ft or over in height), or where foundation conditions warrant, a fourth accelerometer should be located at about mid-height of the principal instrumented monolith or elsewhere on the structure. Concrete dams over 100 ft in height in Zone 2 east of longitude 106°W require only one strong-motion accelerometer. Intake towers over 100 ft in height in Zone 2 west of longitude 106°W require two strong-motion accelerometers with those in Zones 3 and 4 supplemented by peak recording accelerometers. The strong-motion accelerometers should have a maximum operating range of 0.5 g except those installed near the crest of concrete dams over 300 ft high; they should have a maximum operating range of 1.0 g. Strong-motion triaxial accelerometers similar to Model SMA-I manufactured by Kinemetrics, Inc., 336 Agostino Road, San Gabriel, CA 91776, or Model RFT 350 manufactured by Terra Technology, Inc., 3860 148th Avenue N.E., Redmond, Washington 98052, are suitable instruments. Peak recording accelerometers should be similar to Model PRA-100 manufactured by Terra Technology, Inc.

8-4. Hydrodynamic Pressure Measurement Considerations. At dams and intake towers over 300-ft high in Zones 3 and 4, and Zone 2 west of longitude l06°W hydrodynamic pressure gages should be installed to measure the increased pressure of the reservoir water during earthquake occurrences. The gages should be placed in a vertical line on the upstream face of the dam spaced approximately 75 ft apart. On intake towers, they should also be placed in

vertical lines spaced approximately 75 ft apart, but be installed on two orthogonal faces of the tower. Proposed seismic instrumentation should be submitted by Design Memorandum for review and approval.

8-5. Installation and Maintenance. Instruments mounted in the galleries are subjected to high humidity atmospheres, consequently if not protected, they will only realize a short life span due to corrosion. When instruments are specified in galleries, environmental protection, special housings, heaters to keep the instrument and housing dry, and a source of AC power should also be specified. In the past it has been standard procedure to electronically link seismic instruments together to insure that they would all function at the moment of a seismic event. However, it was found that electrical malfunctions, when there was no seismic event, were tripping all the recorders and wasting the recording paper. More recently it has been recommended that recorders not be linked together, but instead to install triggering devices in each instrument to alleviate the problem of accidental triggering of all instruments. Seismic instrumentation should be installed by personnel familiar with its installation. The services of the USGS and WES are available for seismic installation. The equipment should be periodically maintained as required by the manufacturer's instructions.

8-6. Processing of Data. The U.S. Army Engineer Waterways Experiment Station (WES) is assigned the responsibility for analyzing and interpreting the, instrumental data. A report should be sent to USAEWES, Attn: Geotechnical Laboratory, for each project having seismic instrumentation whenever a recordable earthquake occurs. The report on each project should include a complete description of the locations and types of the instruments and a copy of the instrumental records as outlined in ER 1110-2-1802, Reporting Earthquake Effects.